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**Expert Report of Quinn  
C. Horn, Ph.D.**

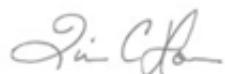
**DH&G, LLC v. HP, Co.,  
et al.**

**Expert Report of Quinn C. Horn, Ph.D.**

**DH&G, LLC v. HP, Co., et al.**

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## Limitations

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Exponent, Inc. (“Exponent”) was retained by counsel for HP, Inc. to review documents, perform analysis and provide opinions and testimony related to the DH&G, LLC v. HP, Co., et al. matter. This report summarizes work performed to-date and presents the findings resulting from that work. The opinions presented herein are made to a reasonable degree of engineering certainty and are based on the investigation as well as the specialized knowledge I have acquired through education, experience, training, and skill. I have made every effort to accurately and completely investigate areas of concern identified during my investigation. If there are perceived omissions or misstatements in this report regarding any aspect of the opinions reached, I ask that they be brought to my attention as soon as possible, so that I have the opportunity to fully address them. I reserve the right to modify my opinions or amend the report if necessary, should additional information become available.

The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any reuse of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user.

## **Report of Quinn C. Horn, Ph.D., P.E.**

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I, Quinn C. Horn, Ph.D., P.E., have been asked by counsel for HP, Inc. (HP) to provide opinions regarding the alleged involvement of an HP laptop computer in the fire at the Bluffs at Evergreen apartments at 2 Casino Rd. Everett, WA 98204 on December 31, 2015. This report sets forth my opinions and the basis for those opinions regarding this matter. The opinions I set forth herein are my own and are based on my investigation in this matter as well as the education, experience, training, and skill I have accumulated in the fields of metallurgical engineering, electrochemistry, and battery science. All of my opinions are held to a reasonable degree of engineering and scientific certainty. I reserve the right to amend or supplement this report subject to additional ongoing discovery.

### **I. Summary of Opinion**

It is my opinion that the alleged HP laptop computer, and associated lithium-ion battery components recovered from the fire scene at the Bluffs at Evergreen apartments did not initiate the fire. Rather, the evidence that I have reviewed is consistent with the lithium-ion cells in this computer failing as a result of exposure to external heat from an encroaching fire.

The following is a list of materials that has been provided to me for review. These items, among other provided documents, provide the basis for my opinions, either in whole or in part.

1. 4<sup>th</sup> Edition of Linden's Handbook of Batteries, 2011
2. UL Standard for Safety for Lithium Batteries, UL 1642, 2004
3. NFPA 921: Guide for Fire and Explosion Investigations, 2011 edition
4. IEEE 1625: Standard for Rechargeable Batteries for Portable Computing, 2008
5. IEEE 1725: Standard for Rechargeable Batteries for Cellular Telephones, 2006
6. Consumer Products Safety Commission Online Database
7. Finegan et al., Nature Communications, April 28, 2015
8. HP's Responses to Plaintiff's Interrogatories
9. HP's Responses to Plaintiff's Request for Production
10. HP Production Documents 000001- 001444

11. Inspection Photos by Don Galler from August 25, 2016
12. Inspection Photos by Jeff Colwell from August 25, 2016
13. 2D X-rays taken by others during on February 3, 2016
14. 2D X-rays taken by others during on August 25, 2016
15. Everett Fire Department Disclosure Documents
16. Everett Police Department Disclosure Documents
17. Plaintiff's Discovery Responses
18. Transcript of Police Interview of Lynn Yevrovich

In addition, I performed the following testing and analyses:

1. Inspection of evidence, including visual inspection at the Jensen Hughes office in Seattle, WA in March 2017
2. Inspection of evidence, including visual inspection, and cell teardown, on August 2, 2017, at the Jensen Hughes office in in Portland, OR.

## **II. Qualification and Experience**

I am currently employed by Exponent, Inc. (Exponent) as a Principal and have been with the firm since July 2004. Exponent is an international science and engineering consulting firm with approximately 900 professional consultants. As a Principal Engineer at Exponent, I provide technical consulting services to clients in the areas of metallurgy and electrochemistry focused on battery technology. In the field of battery technology, my work addresses a broad range of issues including material selection and testing, cell design, cell manufacturing, performance degradation, accelerated life testing, due diligence technology evaluation, and failure analysis. I have worked extensively to develop characterization techniques for understanding electrode reactions and degradation mechanisms that result in performance, safety, and reliability problems in a wide range of battery systems including lithium-ion.

Prior to joining Exponent, I held positions as a Principal Scientist at Physical Sciences Inc. (PSI), and as a Staff Technology Engineer at Energizer/Eveready Battery Company. At PSI, my work focused on the design, development, and testing of high-energy and high-power electrodes for lithium-ion batteries. At Energizer, I was responsible for the Microscopy and Materials Group,

where I conducted failure analysis studies to solve problems related to battery failures and battery manufacturing issues.

I am a Research Affiliate at the Massachusetts Institute of Technology, where I collaborate with researchers in the Electrochemical Energy Laboratory on projects related to electrochemical storage and conversion.

I currently hold three patents in the field of battery technology and have one patent application pending approval. I am the first author of an appendix chapter in the 4<sup>th</sup> edition of the *Handbook of Batteries* on methodologies for failure analysis of batteries. I have also co-authored several publications and given numerous presentations on the topics related to battery performance, reliability, safety, and failure analysis.

I earned my BS and MS degrees in Metallurgical Engineering in 1993 and 1995, respectively, from Michigan Technological University and my Ph.D. in Metallurgical and Materials Engineering in 1998 from Michigan Technological University. I was a Department of Defense Research Fellow while working on my graduate studies from 1994 to 1997.

I am a Licensed Professional Engineer in the State of Maryland and an active member of the Electrochemical Society.

My curriculum vitae is attached to this report, and includes a summary of my experience, along with a complete list of my patents, patent applications, book chapters, publications, and professional presentations. A list of my testifying experience from the last four years is also attached. Exponent is reimbursed at a rate of \$610 per hour for my time through the end of 2021. Neither my nor Exponent's compensation for my professional analysis and testimony is contingent upon the successful outcome of this lawsuit.

### **III. Inspection of Incident Lithium-Ion 18650 Cells and Components**

The remains of three 18650 lithium-ion cells were recovered from the fire scene at the Bluffs at Evergreen apartments by other parties. I first had the opportunity to visually inspect these remains on March 20, 2017 at the Jensen Hughes office in Seattle, WA and again on August 2, 2017 at Case Forensics in Portland, OR. I also analyzed CT scan images acquired from these cells by others during a prior inspection. Photographs of these remains are shown in Figure 1 and Figure

2, and a description of the remains is provided in Table 1 below. 2D X-ray was collected for Incident Cells 1, 2 and 3 and is shown in Figure 6. CT scans were conducted for Incident Cell 1 and Incident Cell 2 and are shown in Figure 7 and Figure 8.

It has been alleged that the incident notebook was an HP 15-AC132DS series laptop computer. This model of laptop computer utilizes a battery pack manufactured by Simplio and consists of three 18650-size lithium-ion cells, with 3 cells connected in series (3S1P). I understand that Samsung SDI, was the approved vendor for 18650 lithium-ion cells for this HP 15-AC132DS series notebook computer.

Table 1: Cell and Component Identification and Condition

Incident Cell #	Condition	Recovery Location	Evidence ID	Weight	Pack Location	Figures
Cell 1	Sidewall Rupture	Bedroom	Item #53 Sample 1	34.6	$V_{Middle}$	Figure 3 Figure 6 Figure 7
Cell 2	Sidewall Rupture	Bedroom	Item #53 Sample 2	33.5	$V_{Low}$	Figure 4 Figure 6 Figure 8
Cell 3	Crimp Release and Sidewall Rupture	Walkway in front of Bedroom	Item #3	7.61	$V_{Positive}$	Figure 5 Figure 6

In addition, I reviewed photographs of the electrical outlet the incident notebook was alleged to have been plugged into<sup>1</sup>. A photograph of the electrical outlet is shown in Figure 9. I also reviewed photographs of the incident AC adapter, AC power cord, and DC output cord.

#### IV. Technical Discussion

The basis for my opinion that the laptop computer battery pack was a victim, rather than the cause, of the fire is based on the following factors:

- i.) no recall history of battery packs for the HP 15-AC132DS series laptop computer,

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<sup>1</sup> HP000805 - 2015-00304080 Fire Report – p. 41.,

- ii.) no reported performance problems for the incident HP 15-AC132DS notebook computer prior to the fire, and,
- iii.) the failure mode of the lithium-ion cells recovered from the fire scene.

Each of these factors is discussed in detail in the following sections of this report.

### ***History of the HP 15-AC132DS Laptop Computer***

Lithium-ion battery packs have been on the market for over 25 years, and the techniques and methods for designing and manufacturing safe, reliable lithium-ion cells and battery packs for portable computing are now well understood by the industry. These techniques and methods are outlined by the Institute of Electrical and Electronics Engineers (IEEE) in *Standard 1625: IEEE Standard for Rechargeable Batteries for Portable Computing*. In addition to this standard, which provides guidelines for designing and manufacturing a safe, reliable battery pack, industry leaders subject their packs to multiple abuse tests outlined by Underwriters Laboratories (UL). The UL tests are designed to validate that the design of the battery pack is robust and that known and foreseeable abuse and misuse of the battery pack and/or computer will not result in a failure that would initiate a fire.

Large lithium-ion battery cell manufacturers produce 18650 lithium-ion cells on large, automated, high-speed production lines. These production lines do an excellent job of producing high quality cells in large numbers.

While this HP 15-AC132DS laptop computer was released in the same year as the event, it has been on the market for several years subsequently without further incidents. Any defect that would lead to a thermal event in the battery would be expected to have manifested in multiple units. It is therefore important to note that there are no recalls or failures, either reported or confirmed, involving overheating or fires from battery packs used in the HP 15-AC132DS laptop computers in the Consumer Products Safety Commission (CPSC) database.<sup>2</sup> If defects were introduced during the manufacturing process of the battery packs or lithium-ion cells, it would be anticipated that other failures of these battery packs would have been reported and that a recall of the cells would have occurred. Given that top tier cell manufacturers (which HP uses to source

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<sup>2</sup> No results were found when searching for “HSTNN-IB7A” in the CPSC Recall List - <https://www.saferproducts.gov/PublicSearch/Result>

cells for its packs) use automated production lines with high quality and efficiency, it is unlikely that one single cell leaving the production line would be defective in a way that might cause it to initiate a thermal event while the remaining cells from that production period were not defective.

### ***Cell Failure Mode***

As discussed by Santhanagopalan *et al.*, only certain types of short circuits have an electronic resistance low enough to allow for a sufficiently high current to induce a thermal event in a lithium-ion cell. Specifically, Santhanagopalan showed through mathematical modeling and experimentation that only a short circuit between the aluminum current collector in the cathode and the active carbon layer in the anode has the right properties to initiate a thermal event in a lithium-ion cell.

In practice, this type of short circuit is difficult to achieve in a real cell because the aluminum current collector and the active carbon layer are separated by the active cathode layer, as shown in Figure 10. In the field, internal short circuits resulting from defects such as contaminants in the cell always start between the active cathode and anode layers, which are both adjacent to the separator. As shown by Santhanagopalan, this type of short circuit will only lead to a small temperature rise and discharge of the cell, not a thermal event. If a cell with this type of short circuit was never recharged, then the failure due to the short circuit would be benign; however, in a device that is used on a day-to-day basis, the likelihood that the battery would be frequently recharged is high. When the battery pack is recharged, the capacity in the cell lost due to the short circuit is replaced, and over time the short circuit may “mature”, as described in the article by McCoy *et al.*, and shown in the plot from that article in Figure 11. This plot shows the maturation of a short circuit intentionally caused by adding metal particulate to an 18650 cell. The “Signal” shown on the y-axis is related to the amount of current that can pass through the short circuit.

The critical factor is that the short circuit will not initiate a thermal event in the cell until the resistance of the short is sufficiently low. If the short has not matured to this point, then the cell will simply self-discharge if the battery pack is not actively being charged. In practice, most battery pack protection circuits used in notebook computers will detect these types of short circuits because the voltage of the affected cell will be lower than the other cells in the battery pack, or will drop below a critical voltage cut-off, per the 2008 IEEE-1625 standard. In either situation, the pack will shut down and become disabled.

The other important point to note is that as the state-of-charge of a lithium-ion cell decreases, the temperature that is required to initiate a thermal event in the cell increases. This is because the cell becomes more chemically stable as it discharges, and the cell has less stored chemical energy that can be converted to heat in the event that an internal short circuit activates. Thus, it is widely accepted in the battery industry that when a lithium-ion cell is below approximately 70% state-of-charge, it will not be capable of initiating a thermal event.

While the state-of-charge of the incident battery at the time of the fire in this matter is not precisely known, the CT scans on the incident cells show that a considerable amount of cathode material remains in these cells, as compared to the CT scan of a cell that was at 100% state-of-charge and failed due to exposure to external heat in the Finegan reference<sup>3</sup> (see Figure 7 and Figure 8). Since it is the chemical reaction between the cathode and the electrolyte that generates most of the heat during a thermal runaway event, one expects most of the cathode to be consumed when the cell is at 100% state-of-charge, as shown in Finegan. The fact that two of the incident cells still have a considerable amount of their cathode indicates that they were not at a sufficient state-of-charge to initiate the critical chemical reaction between the cathode and the electrolyte that is necessary to cause a thermal runaway event. It can be concluded that the artifact cells recovered post-fire at the Davis residence were not at a state-of-charge that would be sufficient to initiate a thermal event that could have initiated the fire.

A battery pack that has initiated a thermal event as the result of an internal short occurring in one cell will typically have one cell in the pack that has substantially less damage than the other cells. Per the 4<sup>th</sup> edition of Linden's Handbook of Batteries:

*“...the electrode windings of an 18650 model lithium-ion cell that initiates a failure in a multicell pack often appear comparatively lightly damaged in x-ray images, while the windings of cells that reacted later show sites of greater damage, including resolidified globules throughout those cells. Little melt damage occurs in the initiating cell because this cell is at or near the ambient operating temperature when it begins developing a short circuit. Much of the energy from this cell can be consumed by the shorting event itself and in self-heating to the critical temperature where the thermal runaway occurs. Once*

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<sup>3</sup> Finegan et al., Nature Communications, April 28, 2015

*the separator melts, there is less energy left in the cell to cause additional pronounced shorting.”*

The above unique conditions were not observed in the remnants of the battery cells at issue. Both Incident Cell 1 and Incident Cell 2 contained a similar degree of resolidification of aluminum and a substantial amount of remaining cathode active materials. Incident Cell 3 experienced a loss of containment and ejected its contents.

In addition to the loss of contents through a side rupture in the cell can or through ejection of cell windings through a detached top cap assembly, the remaining windings in the Incident Cells showed evidence of a gap between the bottom of the windings and the bottom of the cell can. This is indicative of cell exposure to external heat, as uniform gas generation pushes the windings up towards the top of the cell. Increased pressure due to this gas generation can also manifest in bowing of the bottom of the cell can, which was observed in Incident Cell 3.

When a cell is exposed to an external heat source, the venting mechanism can exceed its design limitations, either because the vent is damaged by extreme heat, or because the pressure rise within the cell occurs faster than the vent is designed to relieve it. In these situations, it is common for the pressure in the cell to exceed what is known in the industry as the “crimp release pressure”, which is the pressure at which the stress on the crimped seal exceeds the yield strength of the polymer gasket or the steel can, resulting in the rapid expulsion of the end-cap assembly. Depending on the extent to which the windings are forcibly moved within the cell can, high pressure points can be formed within the cell that can lead to rupture of the cell can on the side or detachment of the top cap assembly. Expulsion of the top-cap assembly is often highly energetic and is sometimes referred to as “explosive disassembly”, “loss of containment”, or “rapid disassembly” of the cell. Similarly, exposure to an external heat source along with heat from a thermal runaway event can soften the steel can of the cell, which coupled with the pressure rise described above can result in rupture of the steel can sidewalls or base. All three Incident Cells appear to have experienced some degree of loss of containment. As noted above, Incident Cell 3 experienced a crimp release. Incident Cells 1 and 2 also experienced loss of containment in the form of side wall ruptures (orange boxes in Figure 7 and Figure 8).

The fact that 18650 lithium-ion cells can expel their contents when exposed to an external heat source such as a fire or flame is well known and established in the industry. Characterizing this

mode of failure is the purpose of the Projectile Test described in the UL 1642 standard for lithium batteries (discussed later in this report). This failure mode is also mentioned in the appendix on battery failure analysis in the 4<sup>th</sup> edition of Linden's Handbook of Batteries, where the following is stated regarding a cell exposed to "external heating of the battery":

*"Maximum damage occurs to the initiating cell here because the shorting and subsequent thermal runaway are so rapid they often result in ejection or partial ejection of the cell windings."*

Therefore, the electrode ejection and/or loss of containment that occurred in Incident Cells 1, 2, and 3 is evidence that these cells were exposed to external heat attack from the fire in the Davis residence.

#### *The Significance of the UL 1642 Standard*

As mentioned earlier in this report, all cylindrical lithium-ion cells contain a venting mechanism that is designed to prevent a buildup of internal pressure sufficient to cause rupturing of the cell can. Testing of the effectiveness of this venting mechanism is an important part of Underwriters Laboratory Standard 1642: Safety for Lithium Batteries. This is a test standard that all lithium-ion cells used in notebook computers, including the subject cells in the incident battery pack, must pass. In this test standard, lithium and lithium-ion batteries are subjected to a series of eleven abuse tests intended to initiate an internal cell fault. One of the requirements for a lithium-ion cell to pass these eleven abuse tests is that the cells do not explode. UL 1642 defines an explosion as "When the cell or battery contents are forcibly expelled and the cell or battery casing is torn or split into two or more pieces." These tests are designed to simulate common use and foreseeable misuse scenarios that could cause an internal cell fault to occur in a cell, and verify that if an internal cell fault does occur that it will not result in the forced expulsion of the internal contents.

It is important to note that UL 1642 contains one additional abuse test called "Projectile Test". In this test, the cell or battery is positioned on a metal screen under an open flame, and, according to the test procedure "*The sample is to be heated and shall remain on the screen until it explodes or the cell or battery has ignited and burned out.*" Therefore, out of the twelve abuse tests that UL 1642 defines, only the Projectile Test where the cell is exposed to an open flame is expected to initiate an explosion event. It is also worth noting that the Projectile Test is the only abusive test listed in the UL 1642 standard that recommends that the test be conducted in a room separate

from the observer due to the potential for an explosive event from the cell exposed to a flame. In other words, the UL 1642 Projective Test is designed to initiate an explosive failure of the cell by exposing the cell to an open flame. Thus, the fact that exposing a lithium-ion cell to an external flame may cause it to expel its contents is thus well known and accepted throughout the industry. Indeed, a cell can expel its contents under UL 1642 and still pass UL safety test. However, more importantly for purposes of this case, because exposure to external fire is known to cause cells to expel their contents, and, is taken into account as part of UL testing, it is entirely incorrect to suggest that expulsion of a cell's contents or lack of containment is indicative of an internal fault. As stated, the UL test often produced this outcome from external flame.

*HP has specific guidelines for pack design that ensure their safety when used with approved cells*

HP vets its cell manufacturers to ensure that the quality of the cells that are installed in its packs is consistently high. All top-tier manufacturers require that their cells pass UL standards - UL 1642 for lithium-ion battery cells. The documents provided by HP confirm that their approved cell manufacturer completed and passed the required testing (See, for example, HP001227-001300).

IEC standards 60050-482:2004 and 62133:2012 distinguish between a “cell” and “battery”, with the latter requiring external housing and protection electronics for installed cells. The HP battery specification provides the required functionality listed by the IEC standards, as individual cell voltages are monitored, over charge/discharge and over current protections are in place such that the cells are operated inside the manufacturer specification, and external housing and circuitry provides protection from wrapper damage and external short circuiting.

HP also requires that the battery packs it receives from pack manufacturers comply with a suite of UL standards, including UL 2054. Testing required to pass this standard includes short circuit testing at room and elevated temperatures, abusive charge and discharge conditions, steady force, mold stress, and drop impact tests. Examples of HP packs passing these tests are provided in HP001302 – HP001311. These documents further confirm that HP packs are safe when utilized as designed.

Lastly, HP also requires that their full laptops are tested according to international standards. In a document issued in February 2015 the laptop Computer from HP was subject to the IEC 60950–

1 suite of tests and passed (see HP001312 – 365). Given that the approved cells, packs, and fully assembled laptops pass all required industry standards, it is clear that these devices are safe when utilized properly.

The extensive testing that the HP devices pass in order to be distributed in the marketplace, and the fact that there has never been a recall or reports of overheating on this model laptop with the OEM batteries, provides significant evidence to rebut pursuers unsupported theory that a an internal short resulted in the fire at the Davis residence.

Additionally, in my experience it is extremely unlikely for a battery to fail without some sort of external stressor, such as thermal, mechanical, or electrical abuse. Currently, “Top tier” manufacturers produce millions of battery cells without incident. In the rare instance that a manufacturing defect does occur that can result in a thermal failure of a cell, typically a subset of the population will contain the defect and many failures would occur in the field. This is rarely, if ever, a one-off event. This is in fact what was seen with the recent Samsung Galaxy Note7 failures and subsequent recall.

### ***Discussion of Jensen Hughes Fire Investigation Report***

Mr. Ken Rice and Mr. Andrew Paris wrote a fire investigation report for the Bluff’s incident in December of 2018. I have several contentions with this report, which include but are not limited to the items discussed in this section.

Mr. Ken Rice and Mr. Andrew Paris conclude in their report that the “fire was caused by an internal failure of the HP laptop Li-ion battery pack” rather than Mr. Davis’s careless behavior. They do so without any evidence to support their opinion. They start by stating that the battery pack area of the laptop was “the most significantly damaged portion of the laptop” and make reference to Figure 10 in their report (Figure 12 here). The image shows a laptop that has been fully consumed by the surrounding fire at the Davis residence. There is no single area of this laptop that is any more or less consumed by fire. Further, given the additional energy that would have been provided to the fire by the external heat attack and subsequent thermal runaway of the 18650 lithium-ion cells installed in the pack, more extensive damage to that area of the laptop would provide no insight as to the origin of the fire.

They go on to state that the incident cells were never exposed to abnormal ambient temperatures – however, given that fact that they were consumed by fire that conclusion is demonstratable false.<sup>4</sup> They further state that there was no evidence that the southeast bedroom ever saw temperatures in excess of 158° F, although clearly the room had been consumed by a fire far in excess of that temperature. As part of their conclusion that the laptop battery pack initiated the fire, Mr. Rice and Mr. Paris's report also states that the venting mechanism for a lithium-ion cell “doesn't always work correctly, especially if the cell shorts internally and the cell temperatures rise quickly.” This statement is incorrect, as the venting mechanism is specifically designed for scenarios where there is an internal short circuit. The venting mechanism can fail if the cell is exposed to external abuse conditions, such as an external short circuit or external heat attack.

In their report, Mr. Ken Rice and Mr. Andrew Paris admit that the “exact determination of the particular failure mode has not been made” for the incident cells. That is to say that they do not know what caused their hypothesized ignition source to start the fire. As I have relayed above, the cells appear to have been the victim of a fire due to the nature of their failure, loss of containment in all three cells including side wall ruptures, gaps at the bottom of the cells (and bowing of the negative end of the cell can in Incident Cell 3), and their likely low state-of-charge at the time of the incident. Mr. Ken Rice and Mr. Andrew Paris have shown no evidence to suggest that one of the cells was the initiator due to an internal cell fault. They also present arguments with no basis in fact to support their hypothesis that the batteries in the laptop were the most probable cause of the fire at the Bluff's complex.

In summary, Mr. Ken Rice and Mr. Andrew Paris provide no evidence to support their various hypotheses and opinions. They merely speculate as to why their hypotheses could be correct, and speculation does not satisfy the Scientific Method, which is the basis for the Basic Methodology section of the NFPA 921 document for conducting a fire investigation.

## V. Conclusions

It is my opinion that the HP laptop computer and associated lithium-ion battery components recovered from the fire scene at the Davis residence did not initiate the fire. Rather, the evidence that I reviewed and the observations I made during my work on this case are all consistent with

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<sup>4</sup> PHILA 0029

the lithium-ion cells in this computer failing as a result of exposure to external heat from an encroaching fire.

My opinions are based on the documents, information, and evidence that I have reviewed to-date, technical literature, my education, experience and training in the fields of metallurgical engineering, electrochemistry and battery science. These opinions are within a reasonable degree of engineering and scientific certainty. If additional information becomes available, this report may be amended or supplemented.



Figure 1. Photograph from March 20, 2017 inspection. IMG\_3917.



Figure 2. Photograph from March 20, 2017 inspection. IMG\_3945.



Figure 3. Photographs of Incident Cell 1. Cite 20160825 Inspection Photos by Jeff Colwell (00276\_0073.jpg).



Figure 4. Photographs of Incident Cell 2. Cite 20160825 Inspection Photos by Jeff Colwell (00276\_0073.jpg).



Figure 5. Photographs of Incident Cell 3. Cite 20160825 Inspection Photos by Jeff Colwell (00276\_0191.jpg).

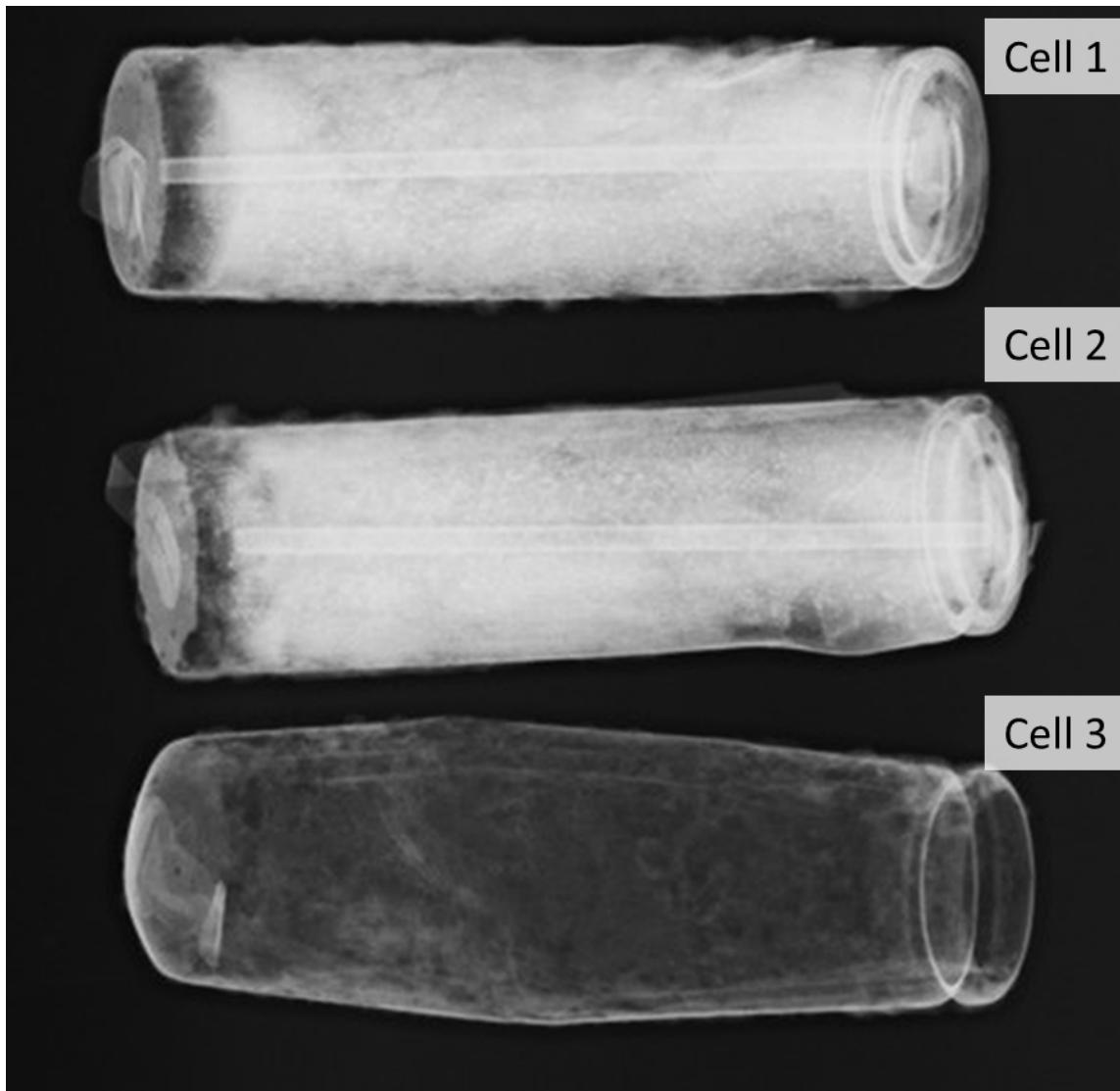


Figure 6. 2D X-Ray images of incident cells. Cite 703257 Radiograph #5004.

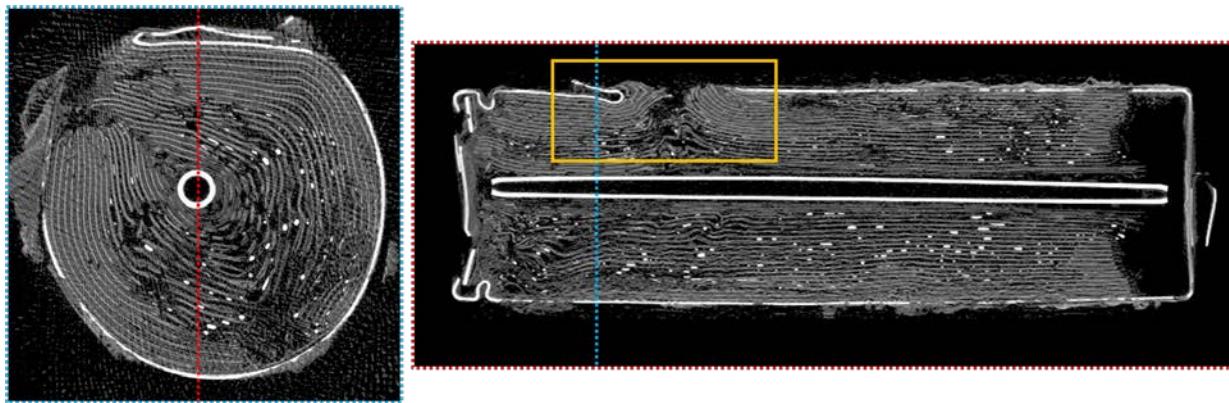


Figure 7. CT virtual cross sections of Incident Cell 1.

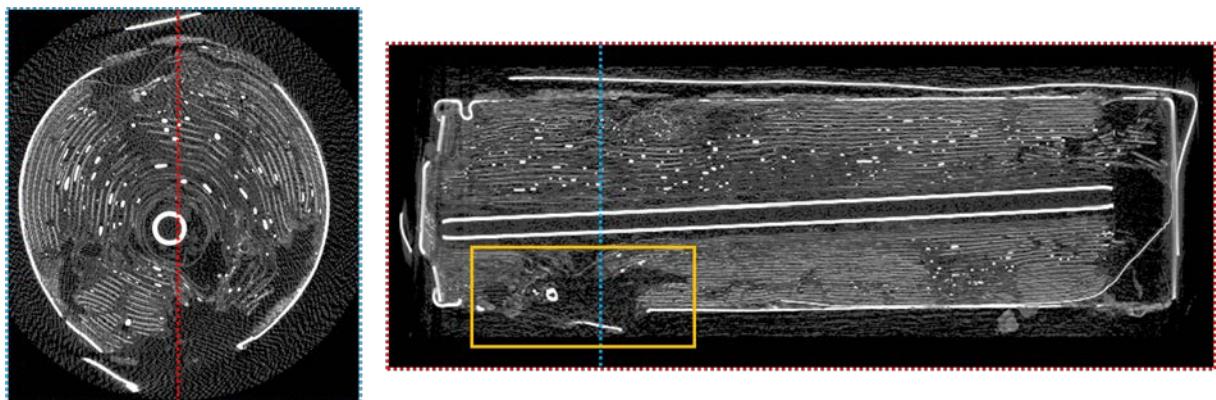


Figure 8. CT virtual cross sections of Incident Cell 2.



Figure 9. Remnants of the outlet and charging cable and adapter.

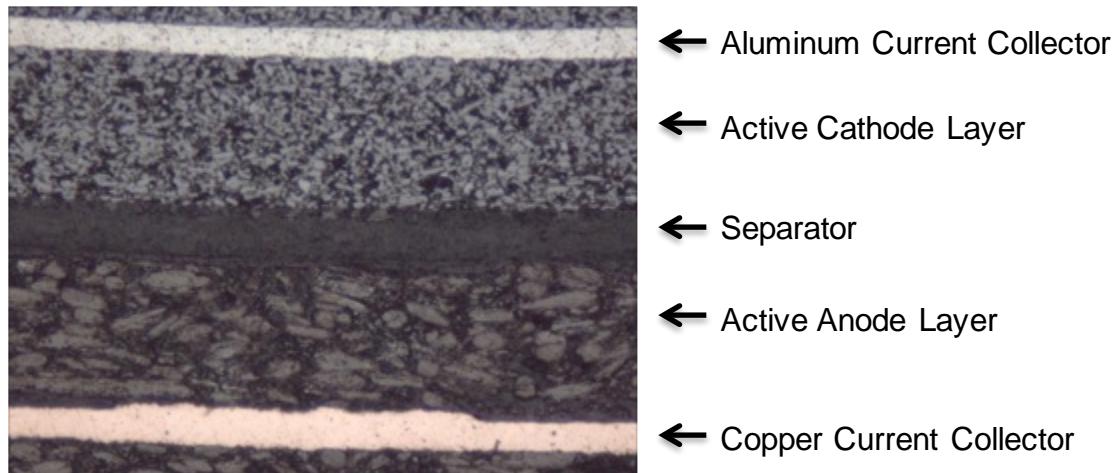


Figure 10. Reflected light optical microscope image showing the electrode layers in an 18650 lithium-ion cell. The thickness of the active layers is approximately 100  $\mu\text{m}$ .

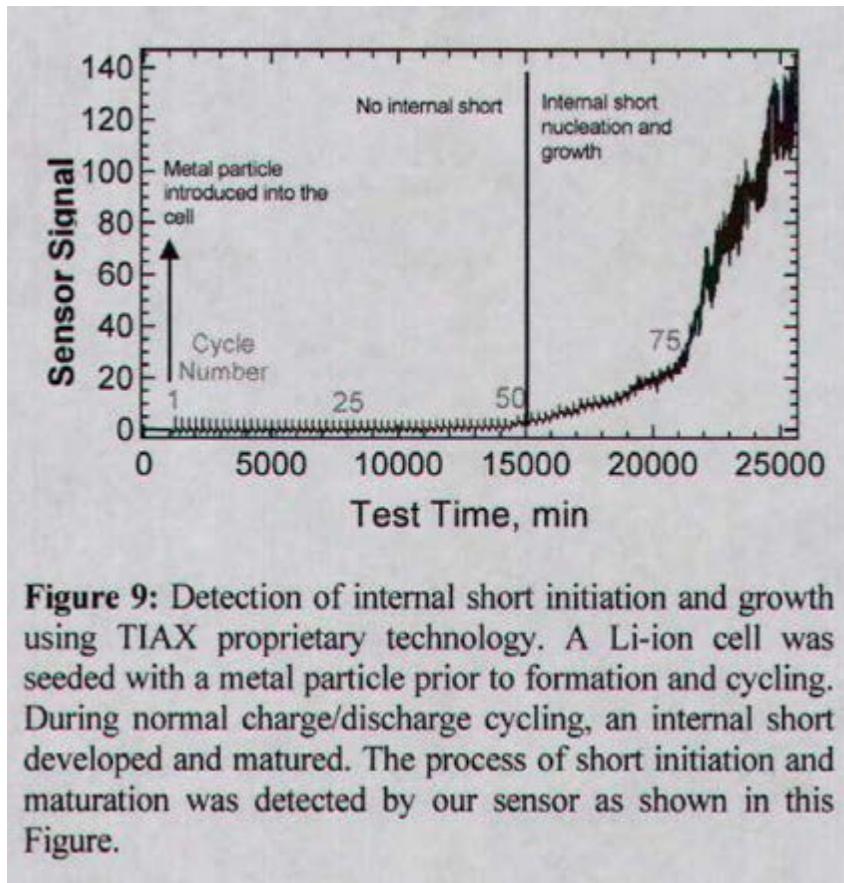


Figure 11. Figure from a proceedings article by McCoy et al. June 2012 showing the initiation and maturation of an internal short caused by the intentional seeding of a metal particle into an 18650 lithium-ion cell.



Figure 12. Figure 10 from the Jenson Hughes Report stating that the battery pack area was “the most significantly damaged portion of the laptop.” PHILA 0014.



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1. **In the Matter of: Certain Lithium Ion Batteries, Battery Cells, Battery Modules, Battery Packs, Components thereof, and processes therefor**  
United States International Trade Commission  
Inv. No. 337-TA-1159  
Deposition, January 17-18, 2020
2. **Taron Malkhashyan v Los Angeles Unified School District *et al.***  
Superior Court of the State of California, County of Los Angeles  
Case No. BC658007  
Deposition, October 3, 2019
3. **Stacia Travis as personal representative of the Estate of Linda Charmel Camp v Asus Computer International and Best Buy Stores, LP.**  
Circuit Court of Garland County, Arkansas  
Case No. 26CV-18-504  
Deposition, July 23, 2019
4. **James Dardini v Sunshine Vapor, LLC, *et al.***  
Circuit Court of the Seventh Judicial Circuit in and for Volusia County, Florida  
Case No. 201610220CIDL  
Deposition, April 19, 2018
5. **Milwaukee Electric Tool Corporation, *et al.* v Snap-On, Inc.**  
United States District Court, Eastern District of Wisconsin  
Case No. 2:14-cv-01296-JPS  
Trial, October 20, 2017
6. **Milwaukee Electric Tool Corporation, *et al.* v Snap-On, Inc.**  
United States District Court, Eastern District of Wisconsin  
Case No. 2:14-cv-01296-JPS  
Deposition, September 19, 2017